Architecture 100

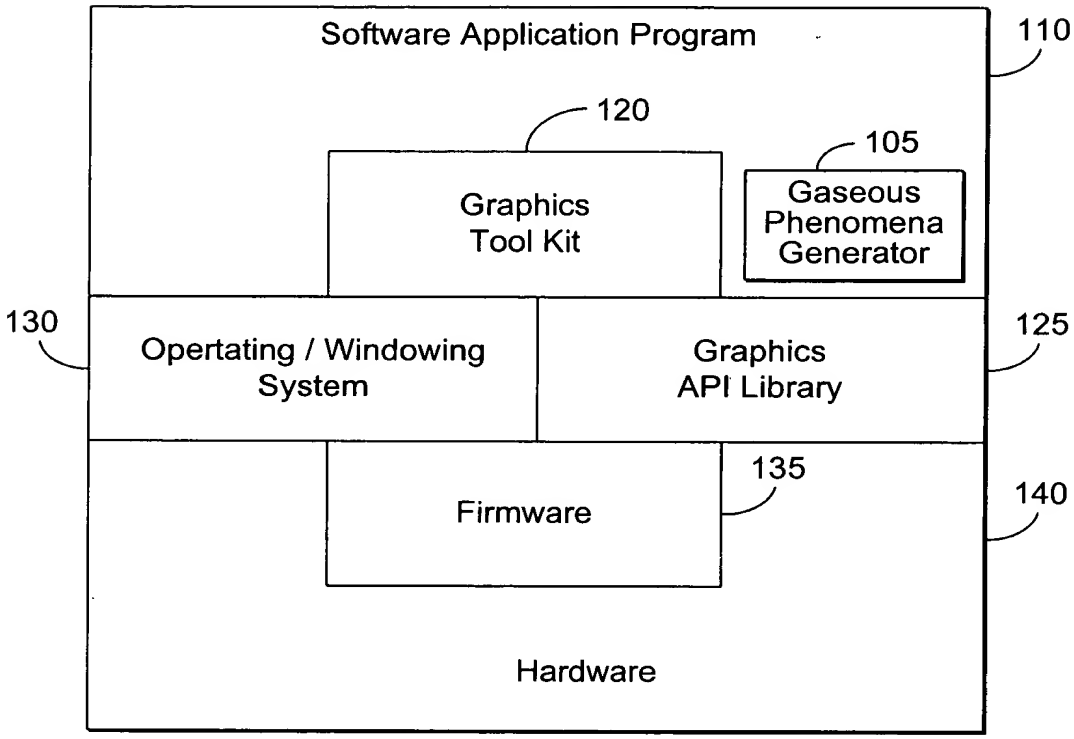



FIG. 1

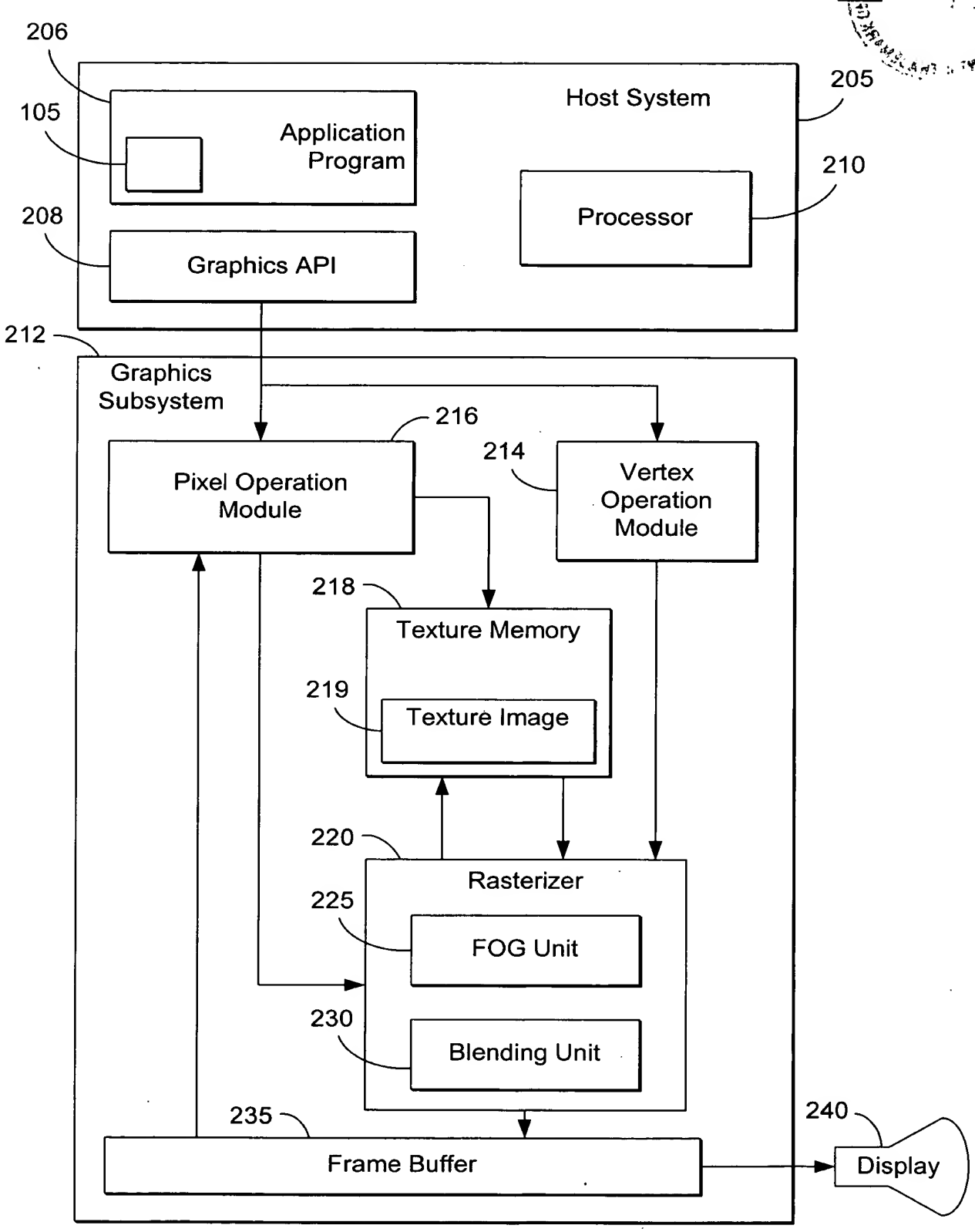

200
206
105
Application Program
Host System
205
210
Processor
208
Graphics API
212
Graphics Subsystem
216
Pixel Operation Module
214
Vertex Operation Module
218
Texture Memory
219
Texture Image
220
Rasterizer
225
FOG Unit
230
Blending Unit
235
Frame Buffer
240
Display

FIG. 2

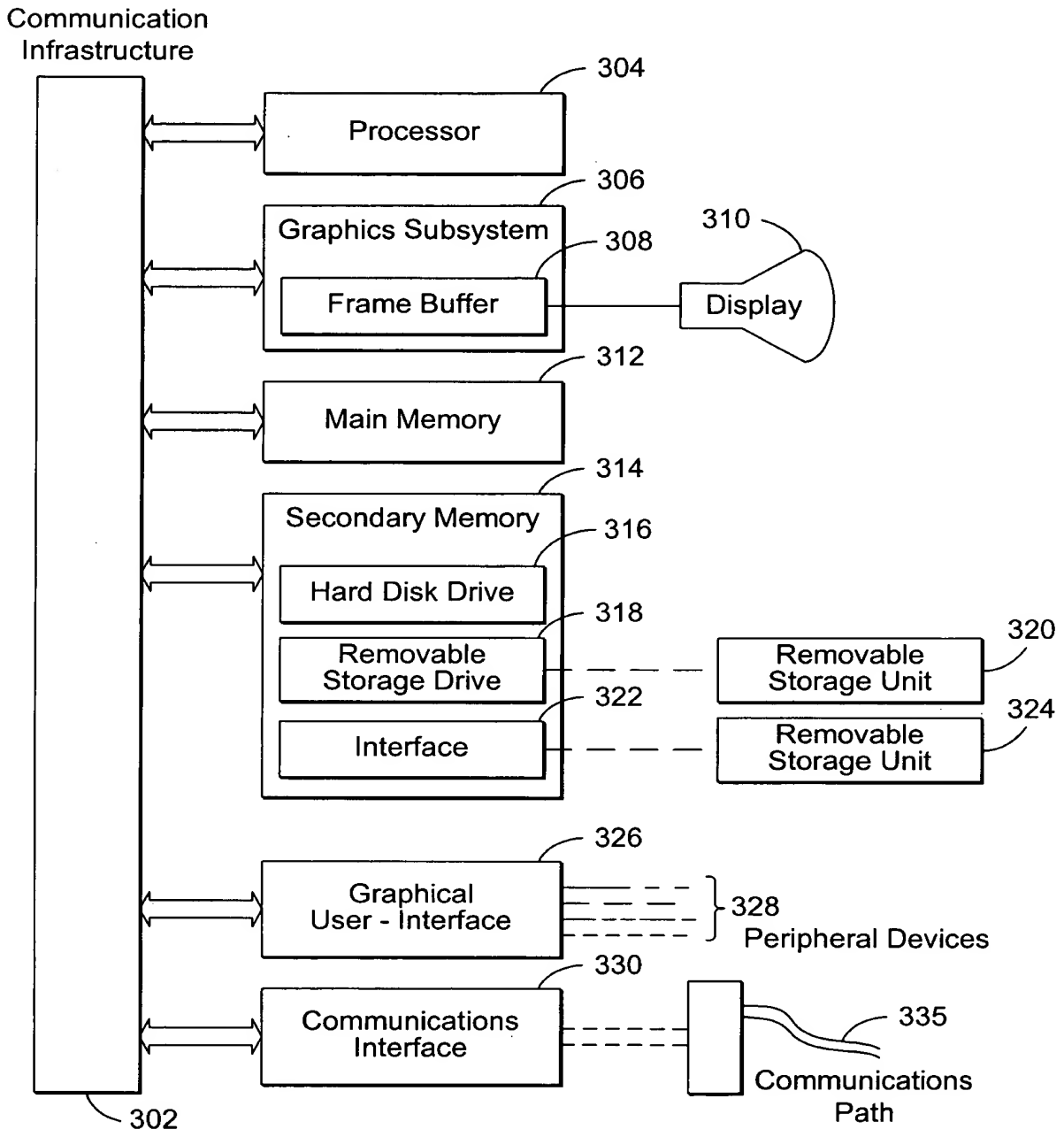

Computer System 300
Communication Infrastructure
304
Processor
306
Graphics Subsystem
308
Frame Buffer
310
Display
312
Main Memory
314
Secondary Memory
316
Hard Disk Drive
318
Removable Storage Drive
320
Removable Storage Unit
322
Interface
324
Removable Storage Unit
326
Graphical User - Interface
328
Peripheral Devices
330
Communications Interface
335
Communications Path
302

FIG. 3

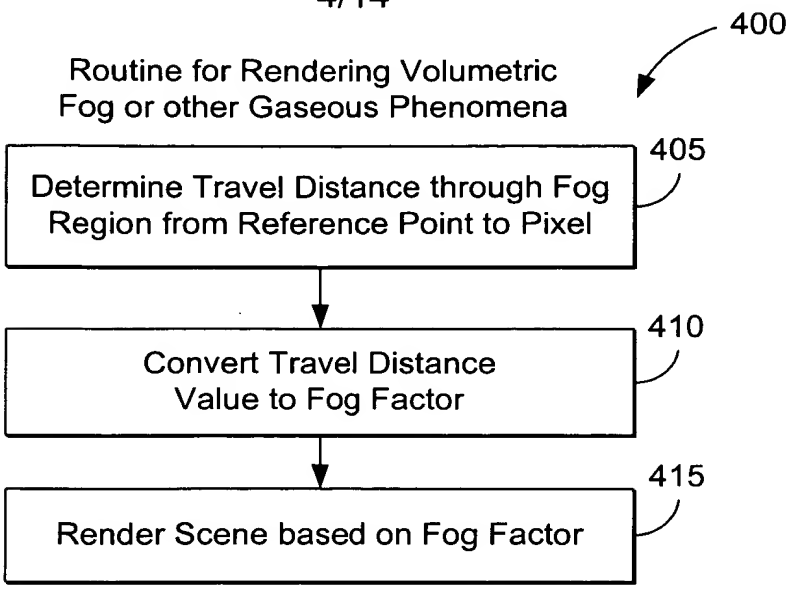

400
Routine for Rendering Volumetric Fog or other Gaseous Phenomena
405
Determine Travel Distance through Fog Region from Reference Point to Pixel
410
Convert Travel Distance Value to Fog Factor
415
Render Scene based on Fog Factor

FIG. 4

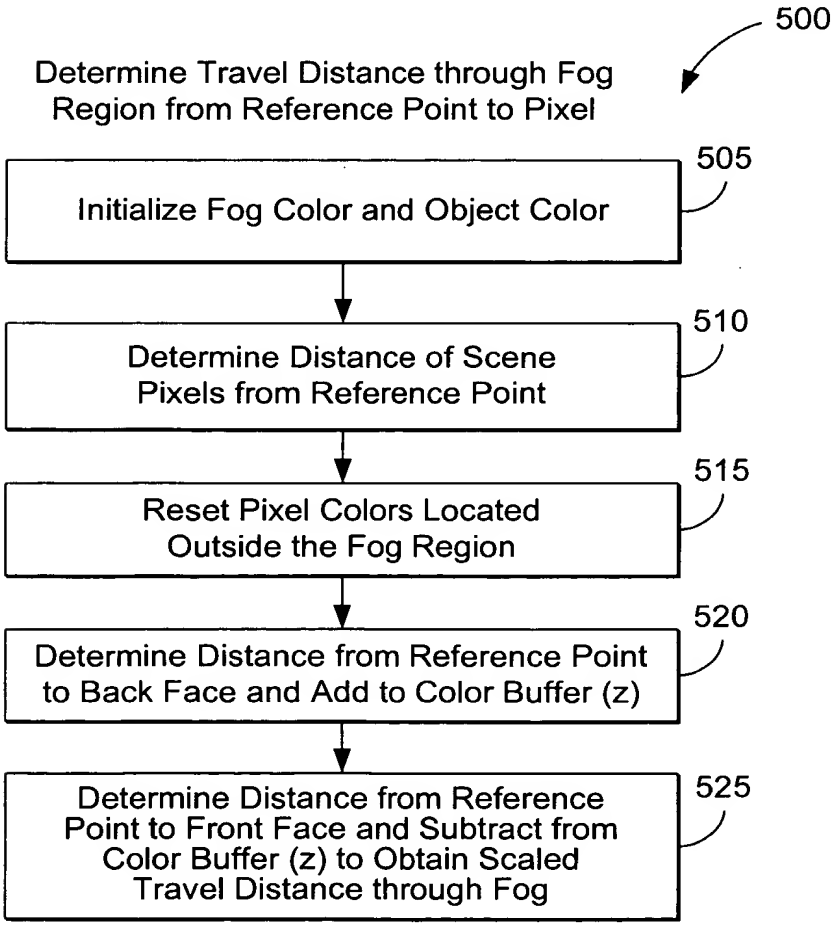

500
Determine Travel Distance through Fog Region from Reference Point to Pixel
505
Initialize Fog Color and Object Color
510
Determine Distance of Scene Pixels from Reference Point
515
Reset Pixel Colors Located Outside the Fog Region
520
Determine Distance from Reference Point to Back Face and Add to Color Buffer (z)
525
Determine Distance from Reference Point to Front Face and Subtract from Color Buffer (z) to Obtain Scaled Travel Distance through Fog

FIG. 5

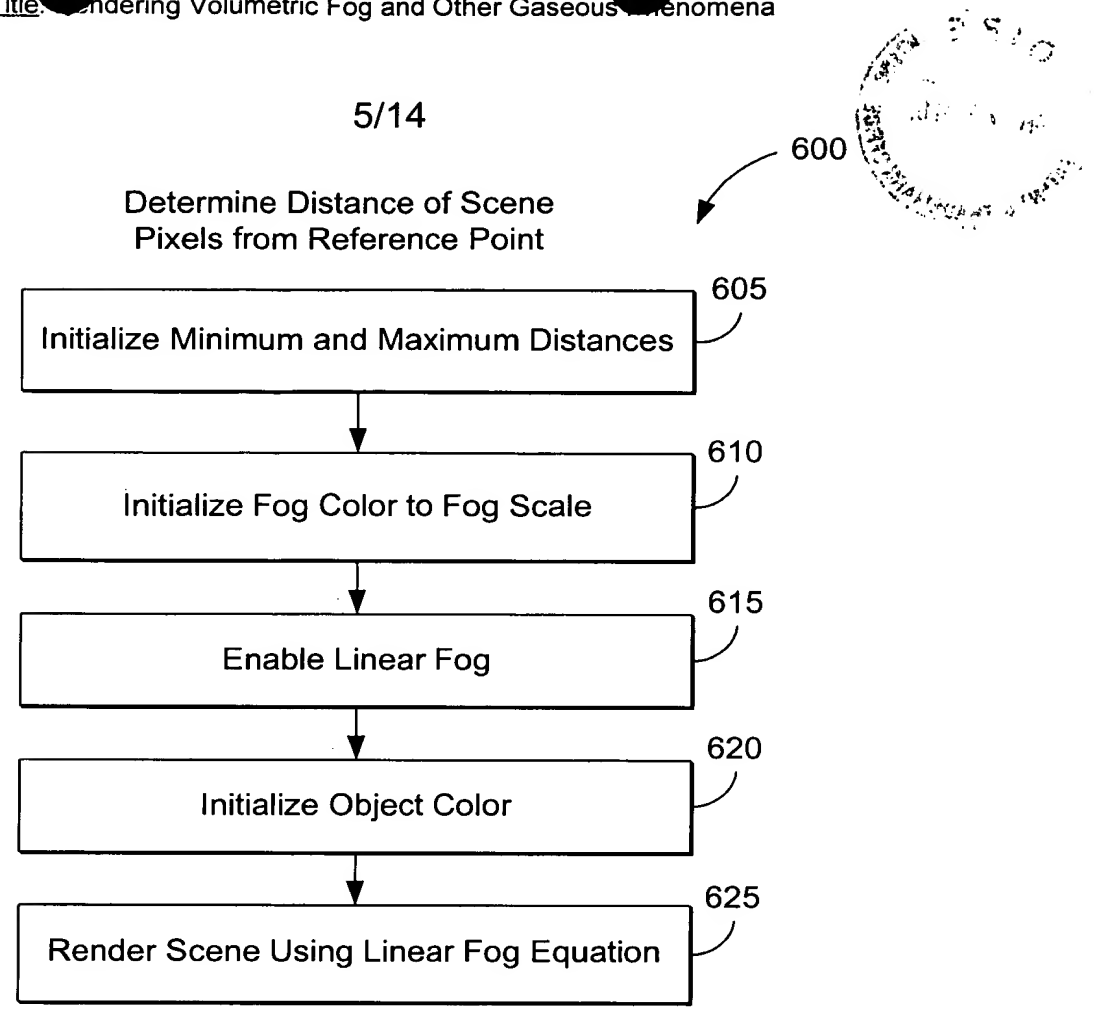



FIG. 6

Linear Fog Equation

Equation One (1)

$$\text{Attenuation Factor}(f) = \frac{\text{Maximum Distance} - \text{Pixel Distance}}{\text{Maximum Distance} - \text{Minimum Distance}}$$

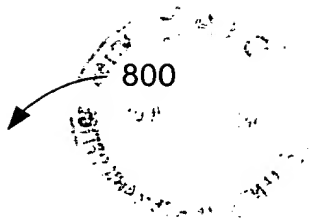
Equation Two (2)

$$\text{Color} = f \cdot \text{Object Color} + (1-f) \cdot \text{Fog Color}$$

Equation Three (3)

$$\text{Color} = \frac{\text{Pixel Distance} - \text{Minimum Distance}}{\text{Maximum Distance} - \text{Minimum Distance}} \cdot \text{Fog Scale}$$

FIG. 7




Reset Pixel Colors Located Outside the Fog Region

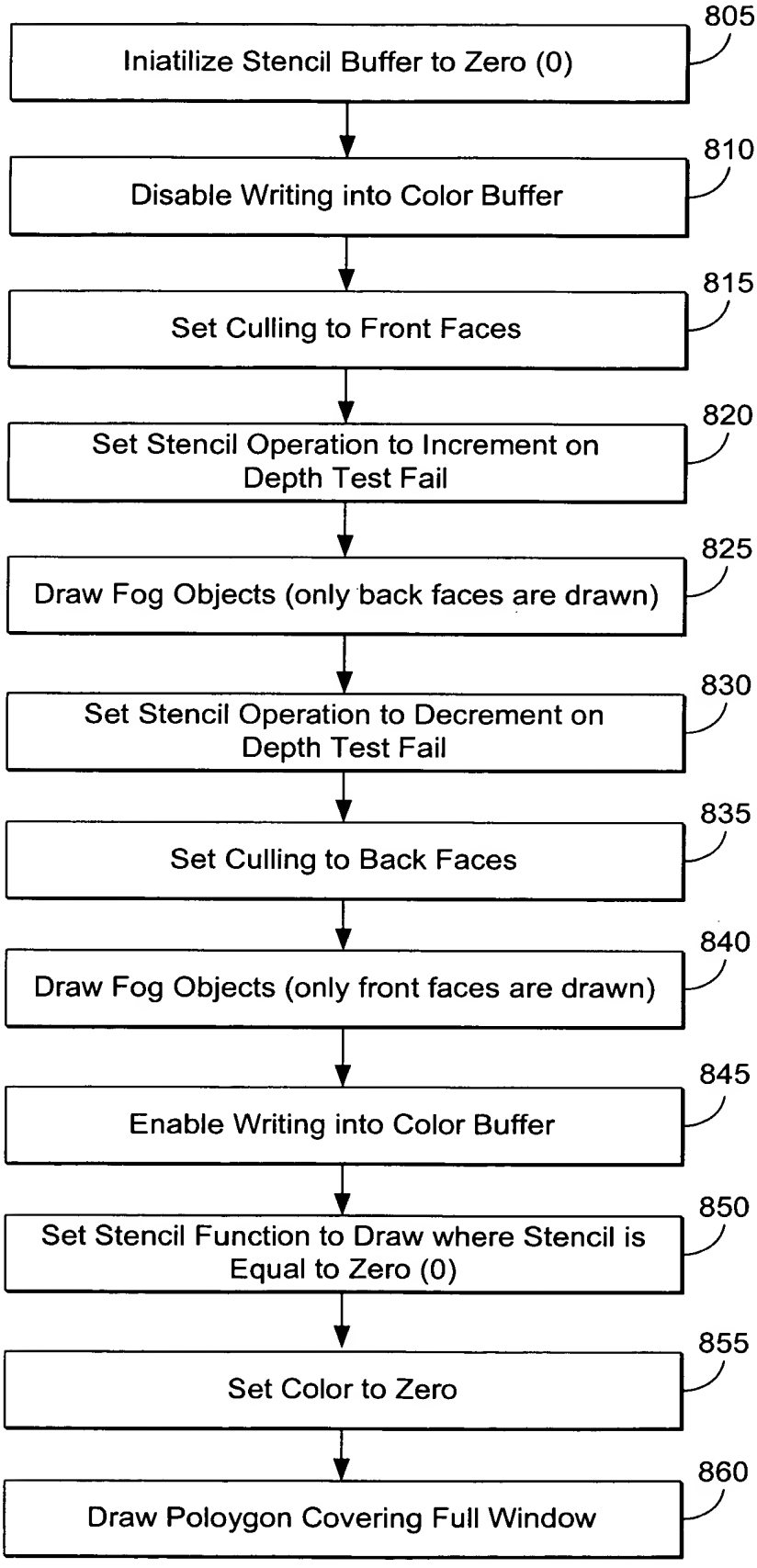



FIG. 8

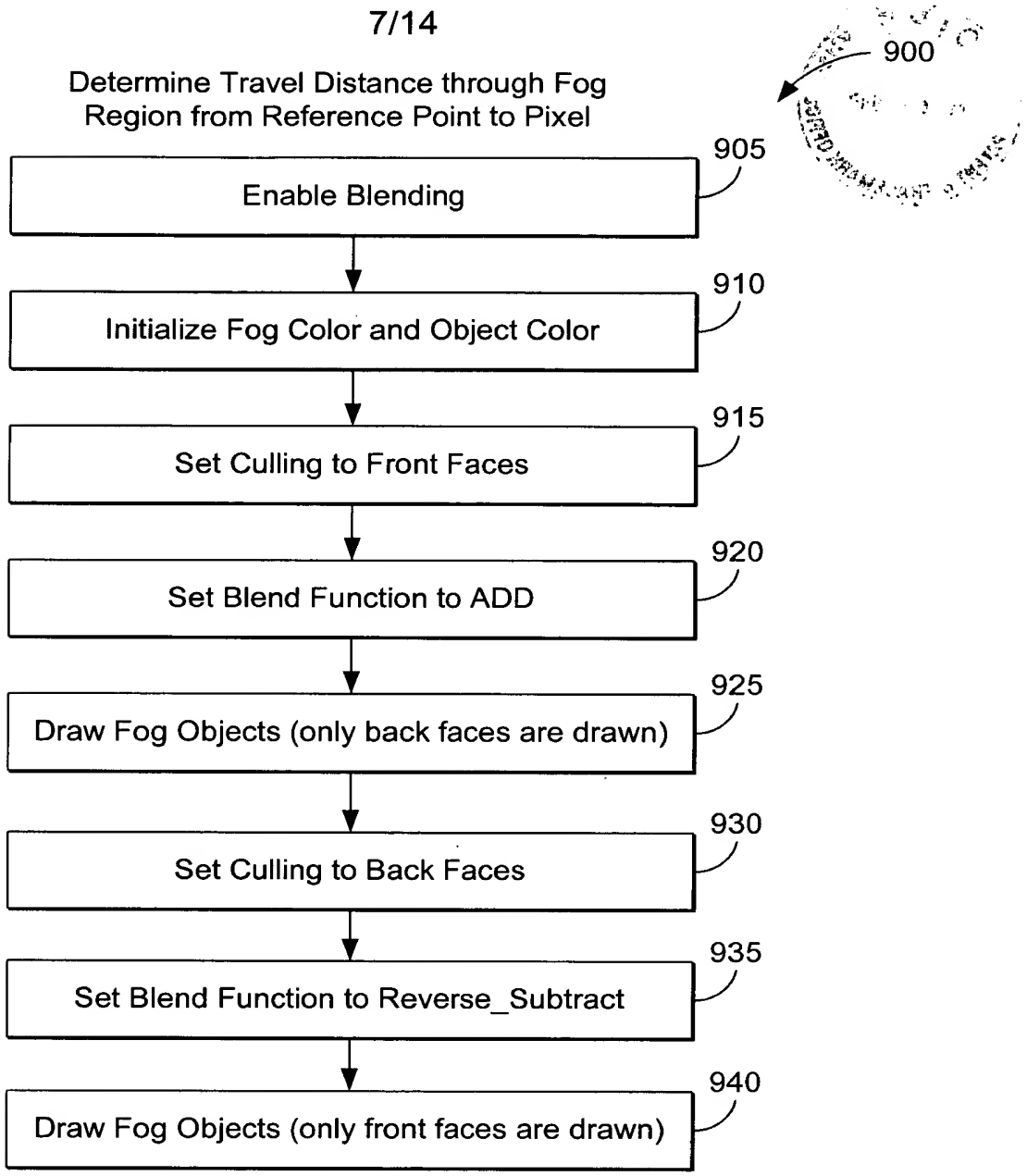

900
Determine Travel Distance through Fog Region from Reference Point to Pixel
905
Enable Blending
910
Initialize Fog Color and Object Color
915
Set Culling to Front Faces
920
Set Blend Function to ADD
925
Draw Fog Objects (only back faces are drawn)
930
Set Culling to Back Faces
935
Set Blend Function to Reverse_Subtract
940
Draw Fog Objects (only front faces are drawn)

FIG. 9

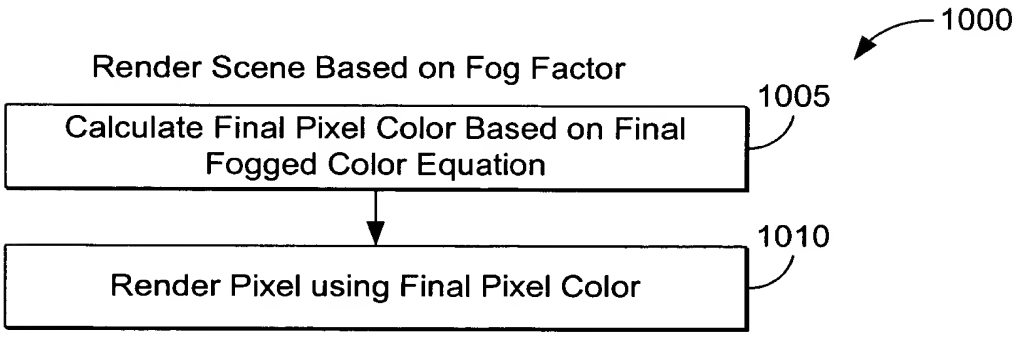

1000
Render Scene Based on Fog Factor
1005
Calculate Final Pixel Color Based on Final Fogged Color Equation
1010
Render Pixel using Final Pixel Color

FIG. 10

Final Fogged Color Equation

Unfogged pixel color • fog factor + fog color • (1 - fog factor)

FIG. 11

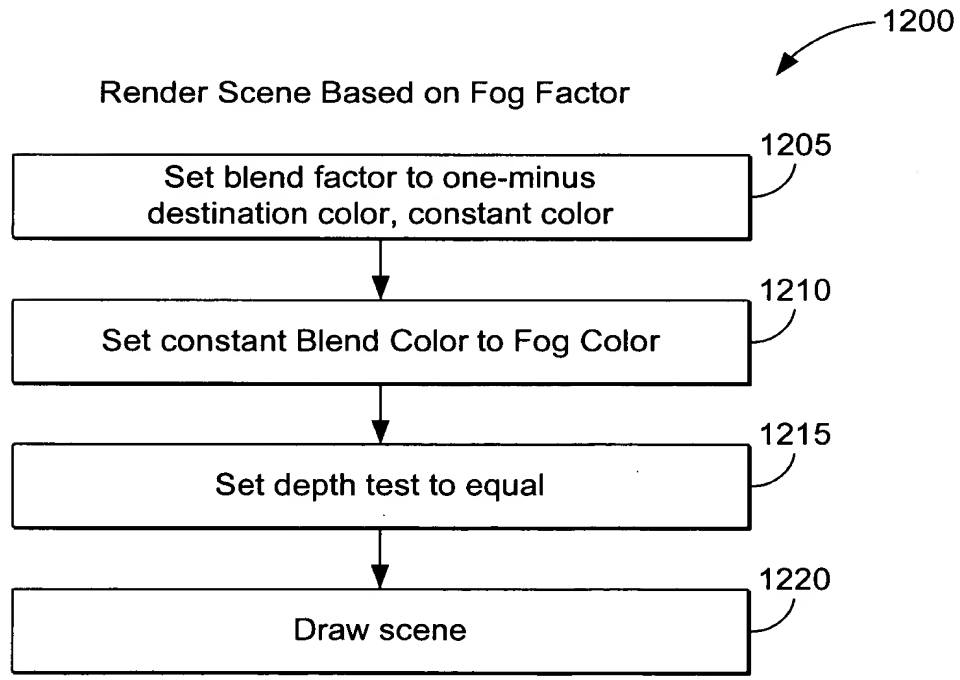



FIG. 12

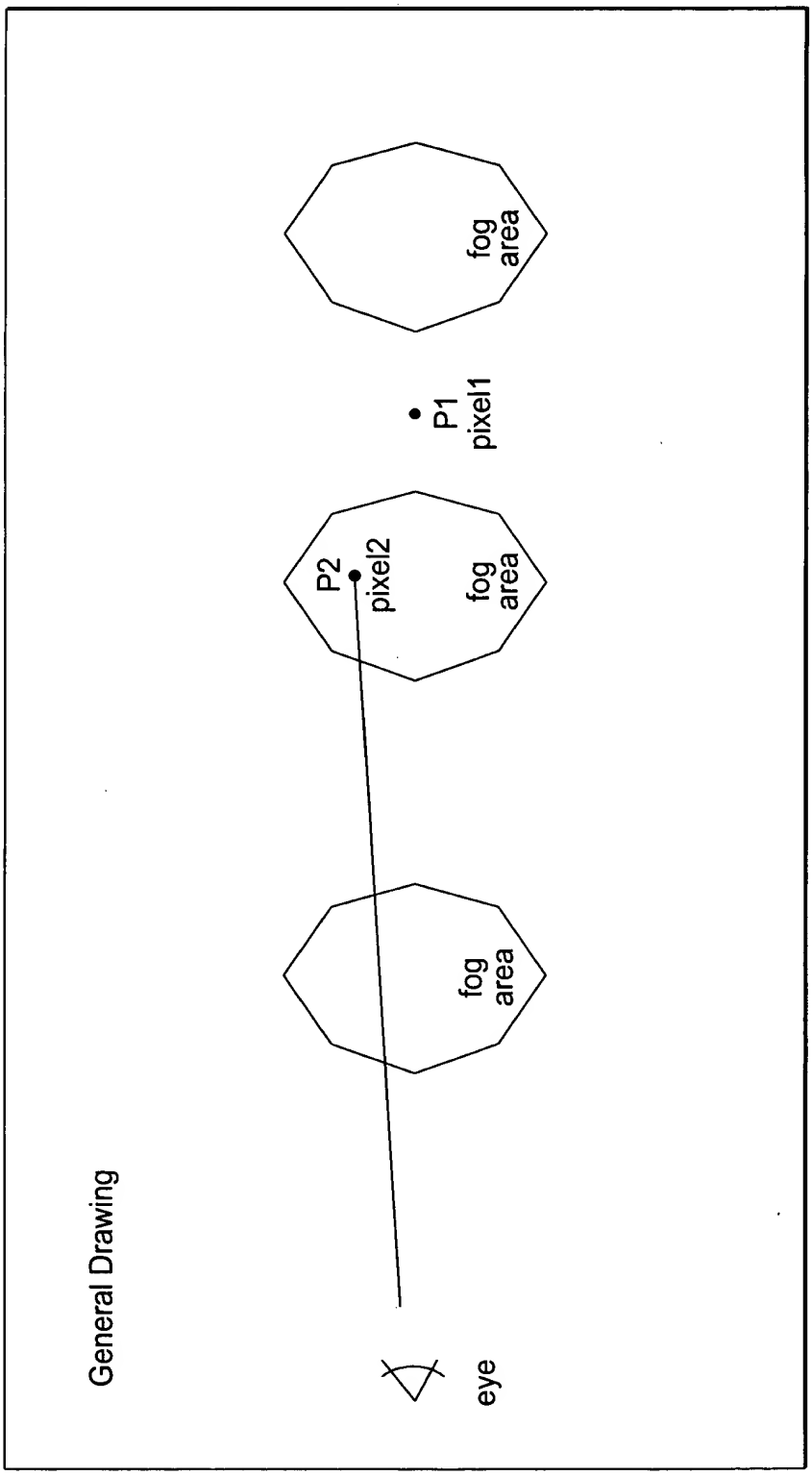

General Drawing
eye
fog area
P1
pixel1
P2
pixel2
fog area
fog area

FIG. 13A

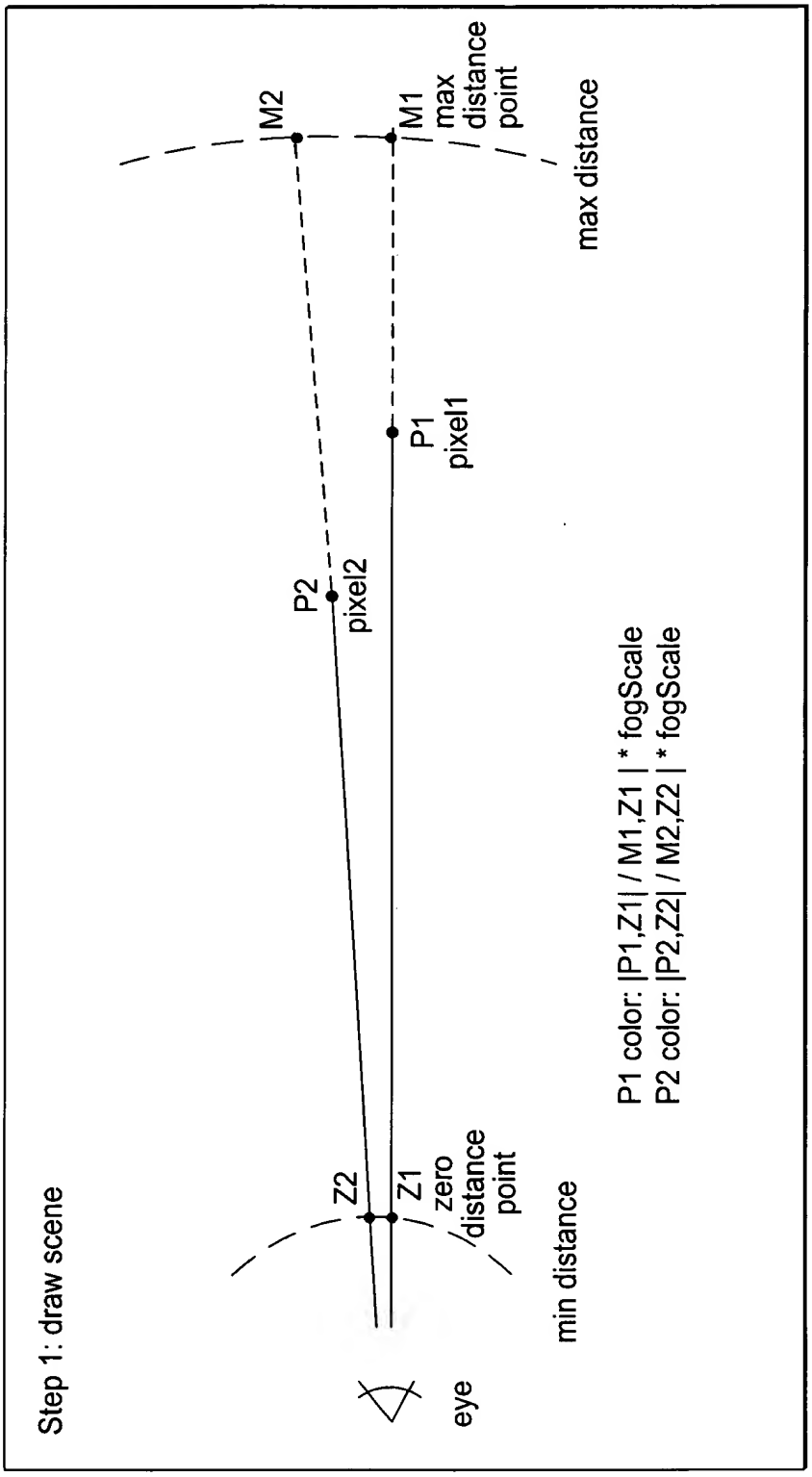

Step 1: draw scene
eye
Z2
Z1
zero distance point
min distance
P2
pixel2
P1
pixel1
M2
M1
max distance point
max distance
P1 color: |P1,Z1| / M1,Z1 | * fogScale
P2 color: |P2,Z2| / M2,Z2 | * fogScale

FIG. 13B

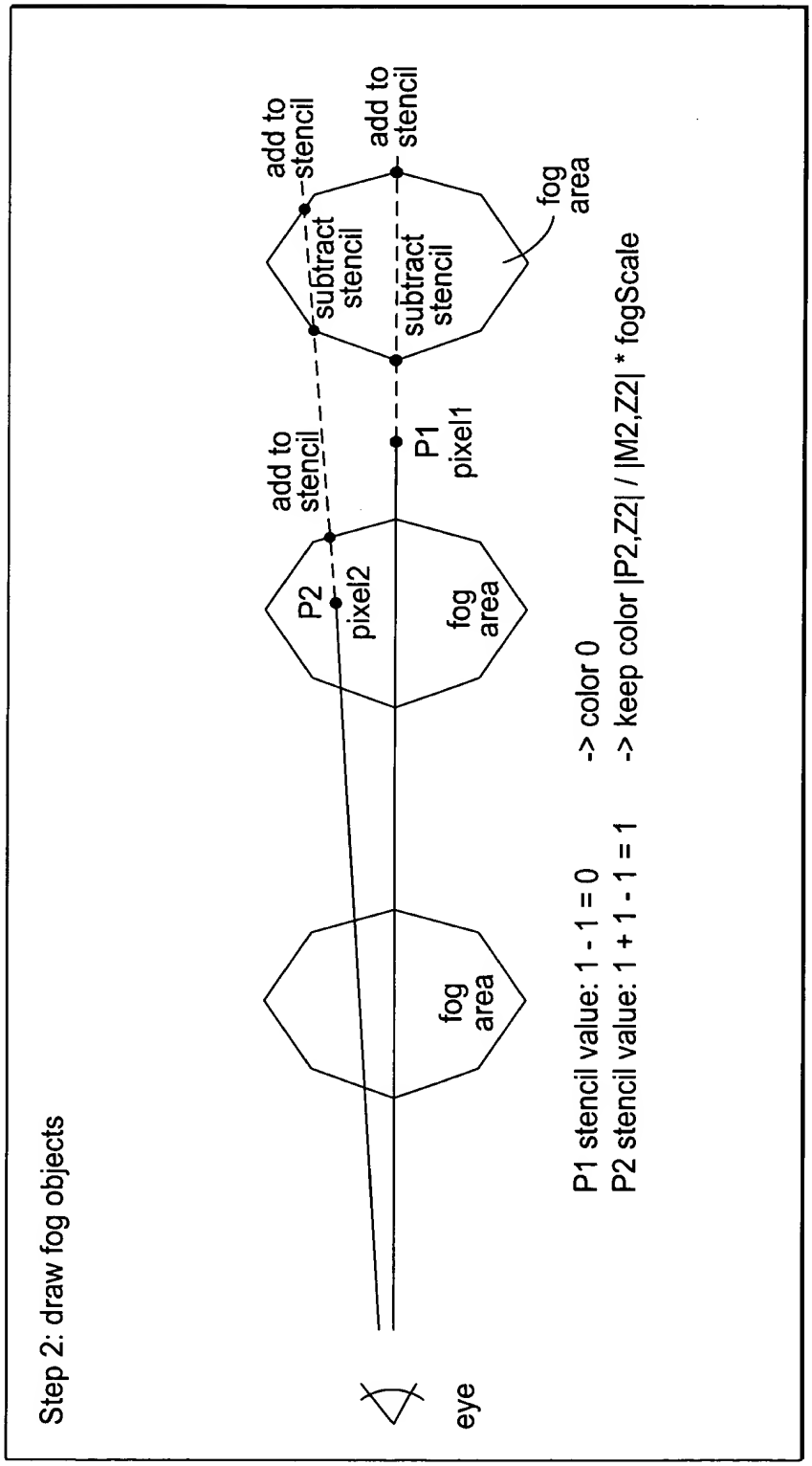

Step 2: draw fog objects
eye
fog area
P2
pixel2
fog area
add to stencil
P1
pixel1
add to stencil
subtract stencil
add to stencil
subtract stencil
fog area
P1 stencil value: 1 - 1 = 0
-> color 0
P2 stencil value: 1 + 1 - 1 = 1
-> keep color |P2,Z2| / |M2,Z2| * fogScale

FIG. 13C

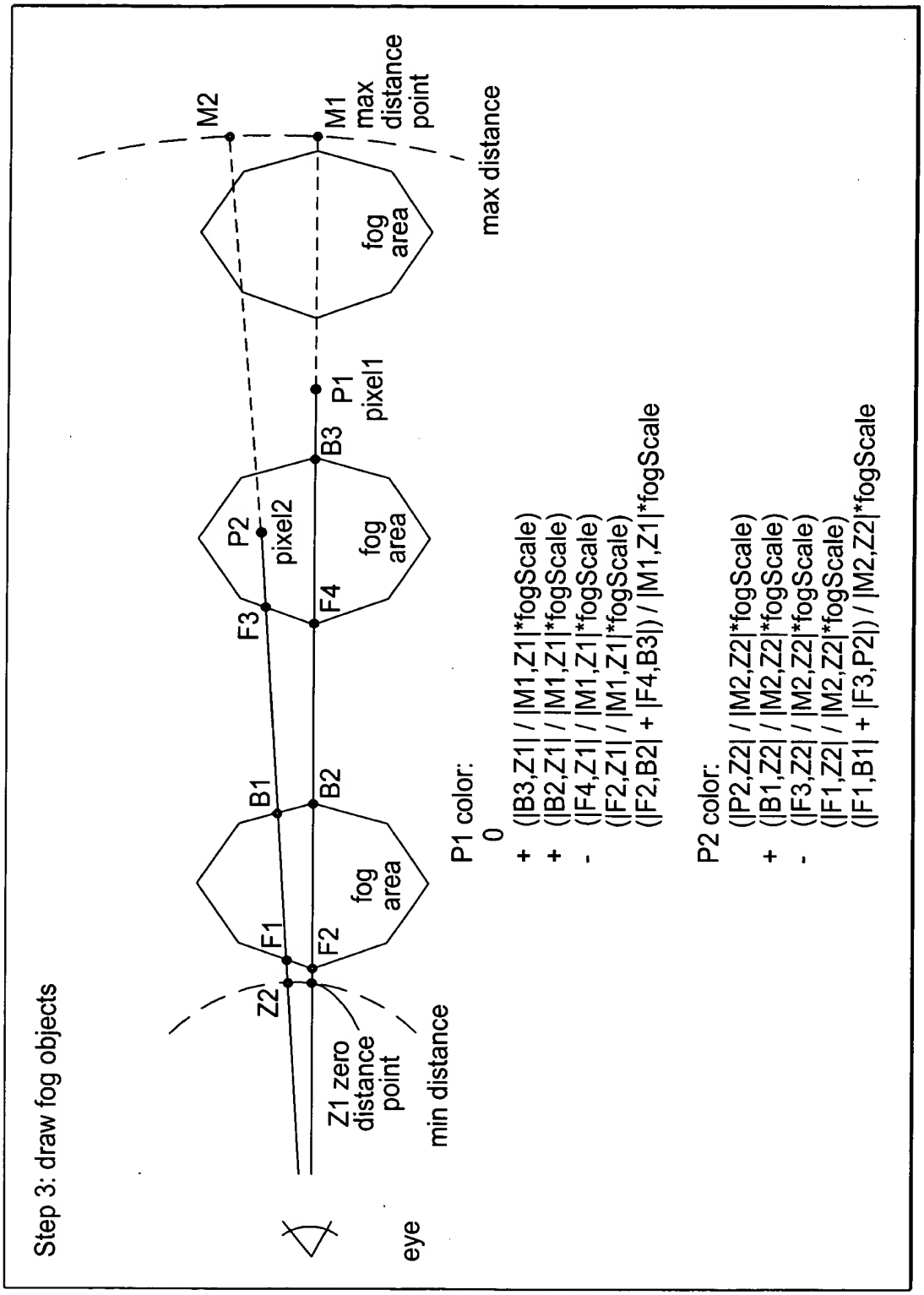

Step 3: draw fog objects
M2
M1
max distance point
max distance
fog area
P1
pixel1
B3
P2
pixel2
F3
F4
B1
B2
F1
F2
Z2
Z1 zero distance point
min distance
eye
P1 color:
0
+ (|B3,Z1| / |M1,Z1|*fogScale)
+ (|B2,Z1| / |M1,Z1|*fogScale)
- (|F4,Z1| / |M1,Z1|*fogScale)
(|F2,Z1| / |M1,Z1|*fogScale)
(|F2,B2| + |F4,B3|) / |M1,Z1|*fogScale
P2 color:
(|P2,Z2| / |M2,Z2|*fogScale)
+ (|B1,Z2| / |M2,Z2|*fogScale)
- (|F3,Z2| / |M2,Z2|*fogScale)
(|F1,Z2| / |M2,Z2|*fogScale)
(|F1,B1| + |F3,P2|) / |M2,Z2|*fogScale

FIG. 13D

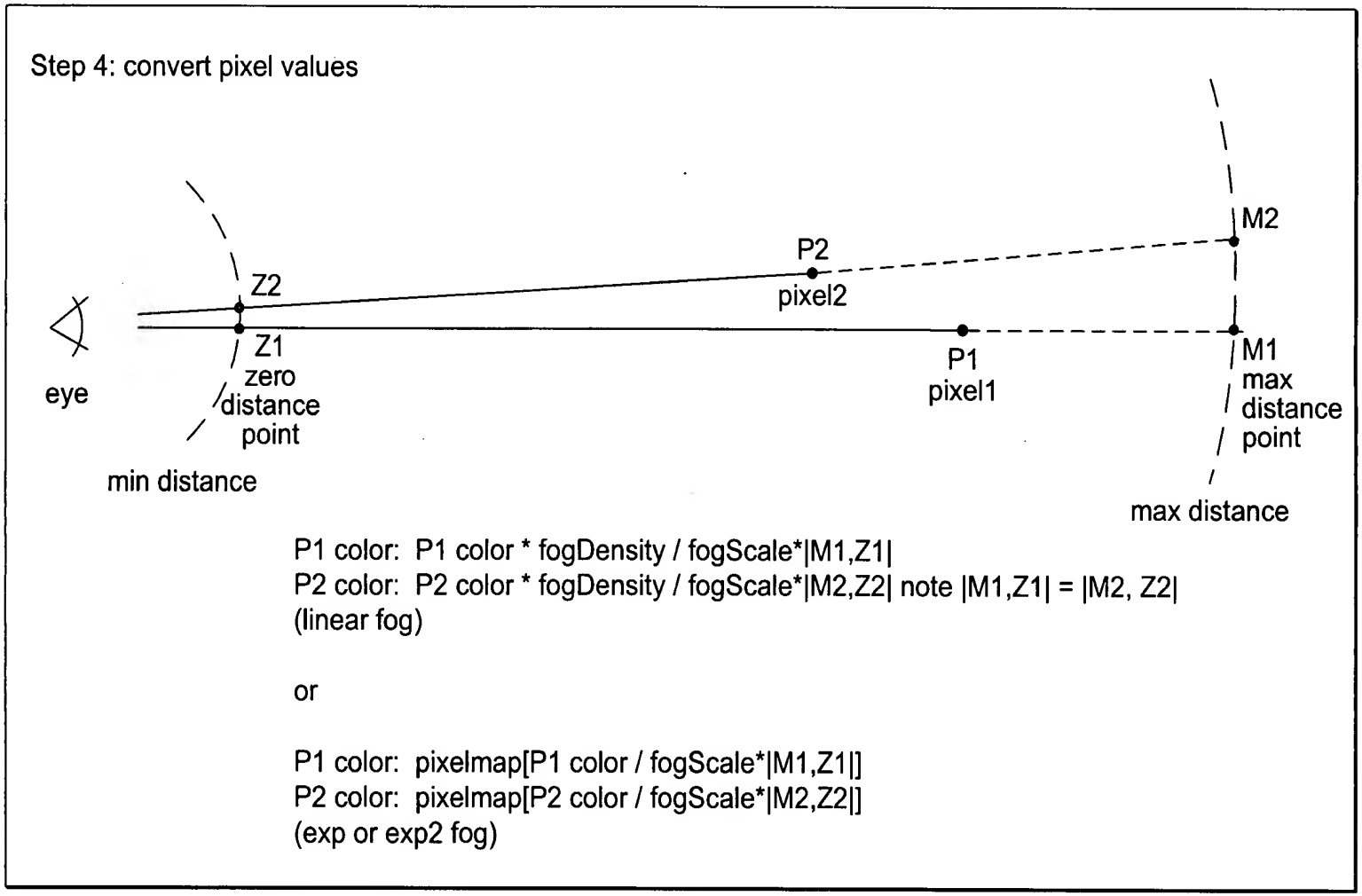

Step 4: convert pixel values
M2
P2
pixel2
Z2
Z1
zero
distance
point
eye
P1
pixel1
M1
max
distance
point
min distance
max distance
P1 color: P1 color * fogDensity / fogScale*|M1,Z1|
P2 color: P2 color * fogDensity / fogScale*|M2,Z2| note |M1,Z1| = |M2, Z2|
(linear fog)
or
P1 color: pixelmap[P1 color / fogScale*|M1,Z1|]
P2 color: pixelmap[P2 color / fogScale*|M2,Z2|]
(exp or exp2 fog)

FIG. 13E

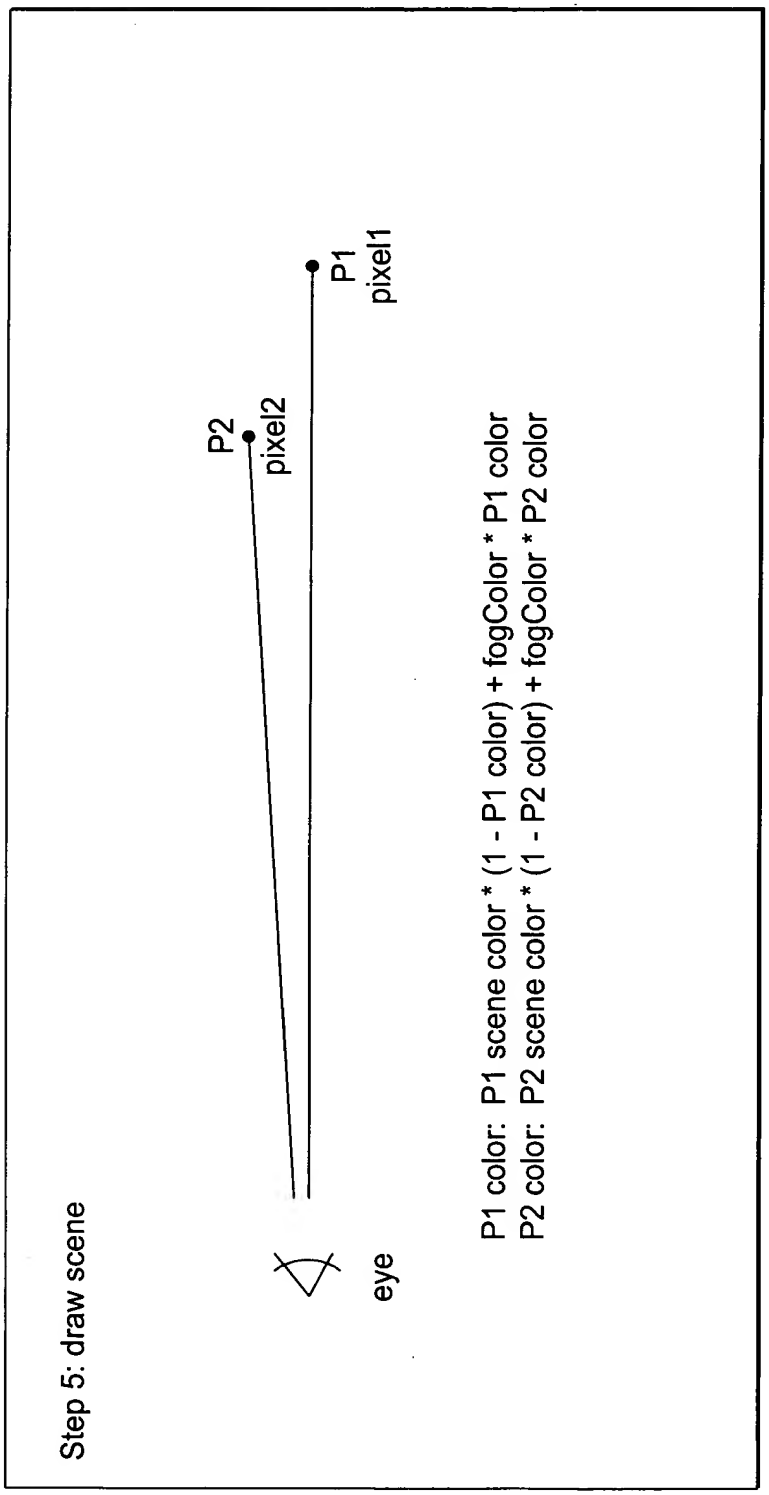

Step 5: draw scene
P2
pixel2
P1
pixel1
eye
P1 color: P1 scene color * (1 - P1 color) + fogColor * P1 color
P2 color: P2 scene color * (1 - P2 color) + fogColor * P2 color

FIG. 13F